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ICE RUNWAY IN THE AREA OF NOVOLAZAREVSKAYA STATION

INITIAL ENVIRONMENTAL EVALUATION

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INITIAL ENVIRONMENTAL EVALUATION (IEE)

ICE RUNWAY IN THE AREA OF NOVOLAZAREVSKAYA STATION

1. INTRODUCTION

Aviation is one of the most important components of Antarctic logistics. From year-to-year, an increasingly greater number of the National Antarctic Programs dispatch their participants to the Antarctic using four entry airfields suitable for receiving heavy aircraft. Three of them are located in the area of the Antarctic Peninsula and present an unpaved airstrip of restricted length. There is only one full-scale ice airfield on the continent at the western Ross Sea coast.

The expeditions of Argentina, Great Britain, Chile and Uruguay fly from South America to the Antarctic Peninsula area. The Argentine airplanes fly to the airfield of the Marambio Base. The British Antarctic Survey maintains the air bridge between the Falkland Islands and the Rothera station. Chile and Uruguay make flights to the Chilean airfield of the Marsh Base on King-George Island.

Airplanes of the National Programs of the USA, New Zealand, and Italy fly to the Antarctic from New Zealand. The US side that maintains the largest Antarctic airfield at the McMurdo station provides the support of these flights.

Australia has declared its intention to establish the air communication with East Antarctica. However, this project is so far at the stage of principle decision development.

Russian aviators have established the shortest air route to East Antarctica from Africa. From 1981 to 1991, this route was used for regular intercontinental flights to the entry ice airfields at the Molodezhnaya and Novolazarevskaya stations.

In 2001, at the COMNAP meeting in Amsterdam, Russia has proposed a plan for resuming air communication with East Antarctica via the South Africa to develop the earlier formulated general concept of the East Antarctic Air Network. Cape Town should become the starting point of intercontinental flights with the ice airfield at Novolazarevskaya station serving as the entry point in the Antarctic. The Antarctic Programs of Germany, Sweden, Norway, Finland, South Africa and Japan have shown their interest in using the runway of Novolazarevskaya to deliver personnel and cargos to their stations in this area.

At the present time, the Russian Antarctic Program reconstructs a full-scale ice runway at Novolazarevskaya as an alternate airfield for the future construction of airfield at the Progress station. As shown by previous experience, ice airfields can be constructed and successfully used for serial aircraft at very low cost and with a minimum environmental impact.

2. GENERAL INFORMATION

2.1 Legislative base

In 1991 in Madrid, the Antarctic Treaty Consultative Parties, including Russia, have signed the Protocol on Environmental Protection to the Antarctic Treaty (hereinafter referred to as the Protocol), which has put forward the environmental protection issues as the most critical obligations of the States, Parties to the Antarctic Treaty. According to the Protocol, Antarctica was designated as a natural reserve and a natural scientific laboratory of world importance that should be preserved for future generations. On May 24, 1997, the Russian Federation has ratified the Protocol at the Federal Law level. In January 1998, the Protocol has come into legal force after being ratified by all Consultative Parties.

After ratification of the Protocol, the Decision of the Government of the Russian Federation of December 18, 1997 No. 1580 “On ensuring the implementation of the Protocol on Environmental Protection to the Antarctic Treaty” was adopted. The Federal Service of Russia for Hydrometeorology and Environmental Monitoring (Roshydromet) was entrusted with the functions of providing coordination and organization of work of the Federal executive bodies for fulfilling the obligations of the Russian Federation. The Roshydromet was authorized to issue permits to the Russian individual persons and legal entities for activity in the Antarctic as agreed with several Ministries and Agencies based on the Conclusion on the Assessment of the impact of this activity on the Antarctic environment and the dependent and related ecosystems.

Further step in the Protocol implementation was the Decision of the Government of the Russian Federation of December 11, 1998 No. 1476 “On the adoption of the Procedure for consideration and issuance of permits for activities of the Russian individual persons and legal entities in the Antarctic Treaty Area”. The Procedure defines types of activity requiring a permit, terms necessary to obtain a permit for the proposed activity; processing of applications and necessary documents for the activity including an environmental impact assessment, and control for observing requirements to the activity in the course of its conduct and penalties.

According to the requirements of the Protocol and the Russian legislature, any activity in Antarctica before its commencement has to be preceded by an Environmental Impact Assessment (hereinafter, EIA). The EIA procedures are set forth in Annex 1 to the Protocol.

The present EIA was performed in accordance with the EIA procedures set forth in Annex 1 of the Protocol and the documents that take into account the specific features of RAE activity and were submitted by Russia to ATCM XXII. It contains information specified in the “List of evidence to be included to the data on environmental impact assessment of activity planned in the Antarctic Treaty Area” (adopted by the Roshydromet order No. 139 of December 12, 1999).

2.2. Aims and goals of intercontinental flights from Africa to East Antarctica

Throughout the last decades, many National Antarctic Programs undertake practical efforts to increase the efficiency and safety of air operations. However, one of the most important components of this international Antarctic cooperation is a concept for creating a joint network of airstrips in Antarctica capable to receive heavy wheel aircraft. In this sense, resuming flights from South Africa to the runway, which is now reconstructed at Novolazarevskaya station, should become a decisive factor in creating a joint air network in the Antarctic (Fig. 2.1).

Intercontinental airlines connecting Africa and Antarctica will have large advantages both for many national scientific programs operating in this region and for environmental protection. The main results of reconstructing the ice runway at Novolazarevskaya station could be formulated as follows:

- improvement of human safety indicators in the Antarctic;
- decrease of the general environmental impact produced by the existing transportation system based on marine shipping;
- possibility of the earlier start of seasonal operations at the continent and increase of their total duration;
- increase of the efficiency of scientific studies due to a simplified personnel rotation and smaller time of delivery to the Antarctic;
- possibility for research managers to participate in the field Antarctic studies and improve significantly the results of activity under the international projects.

The Novolazarevskaya station is located in the central area of the Queen Maud Land. The National Antarctic Programs of Germany, Sweden, Norway, Finland, South Africa and Japan have their stations in this area. Every year, hundreds of polar explorers arrive to the region and depart by sea transport. Neither of these national programs has a direct access to the area by intercontinental aircraft. In addition, the runway at Novolazarevskaya station can be used as the starting point for inland flights in East Antarctica, which will simplify the logistics operations for many of the aforementioned European and Asian countries.

2.3. Experience of the Russian Antarctic Expedition in construction of ice runways and operation of the intercontinental Africa-Antarctica airlines

The Russian Antarctic Expedition has already used air communication between Africa and Antarctica. Two entry airfields were constructed near the Molodezhnaya and Novolazarevskaya stations that were used during the period 1981-1991. Regular intercontinental flights to the Molodezhnaya and Novolazarevskaya stations were made from Maputu (Mozambique) and Cape Town (South Africa). The flights were made in October-February. The IL-76TD and IL-18D aircraft were used for intercontinental flights.

The Molodezhnaya airfield was constructed in 1981 in 10 km to east of the station near the Vechernyaya Mount. The airstrip was made in the form of a hard pavement from compacted snow above deep natural snow. The airstrip had the following dimensions: 2540 x 42 m and a course of $140^o/320^o$. The airfield infrastructure included 4 living houses, power station, hangar, warehouse, repair shop, mobile refueling units and radio-navigation equipment. The last time when the runway at Molodezhnaya was prepared for operation was in November 1992.

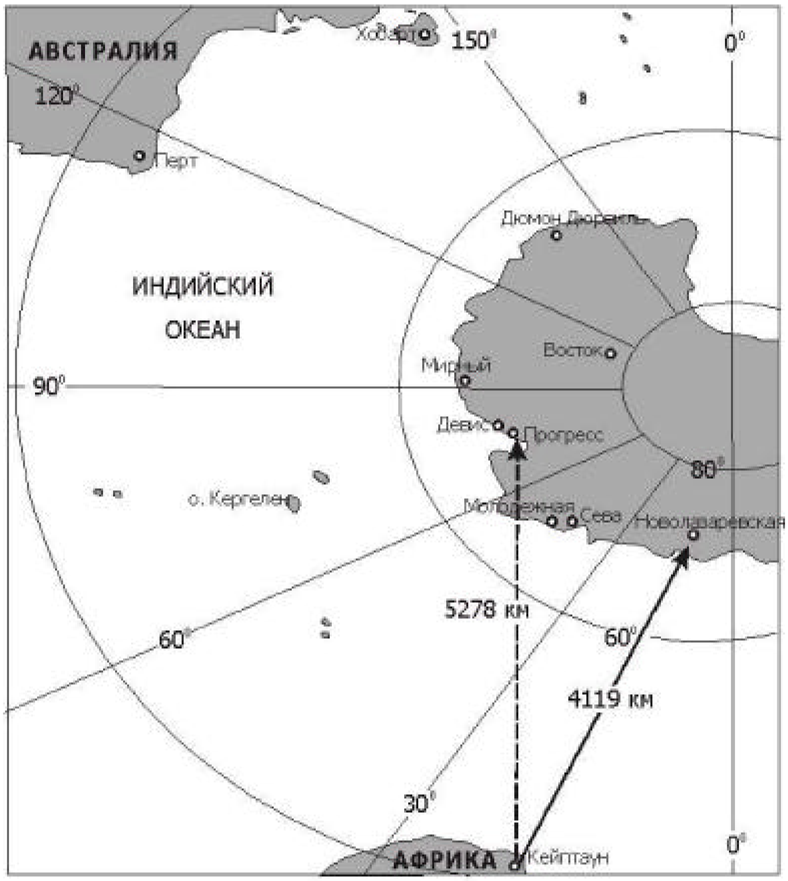


Рис. 1. Расстояние в километрах от Кейптауна до ВПП на ст. Новолазаревская и проектируемой ВПП на ст. Прогресс

Fig. 2.1. Distance in kilometers from Cape Town to the airstrip at Novolazarevskaya station and to the airstrip designed at Progress Base

The airfield at the Novolazarevskaya station was used as an alternative to Molodezhnaya. The runway was located in 15 km southward of the station on blue ice. The upper runway point is 550 m as high as the sea level. The runway was constructed as a blue ice band protected by a thin layer of compacted snow. The runway dimensions are 2760 x60 m and the operation course is 106^{o}. The airfield infrastructure includes 2 living houses, power station, warehouse/repair shop and mobile refueling units and radio-navigation equipment. The last time when the airfield at Novolazarevskaya was prepared for operation was in November 1994, but it was not used for landing of heavy aircraft.

IL-76 is one of the most efficient aircraft for long-range transportation operations. It is equipped with pneumatic winches, electrical telphers, a cathead and a flap ramp. This equipment onboard allows making any cargo operations on unequipped airfields. For flights to the Antarctic, these airplanes were modified to ship passengers and cargos by one flight. The airplane can transport up to 50 passengers and 15 t of cargo. In August 1991 during the emergency flight from Molodezhnaya station to Cape Town, there were 135 passengers onboard IL-76 TD. IL-18D was predominantly used as an air laboratory for execution of different scientific programs (Table 2.1).

Table 2.1. Characteristics of heavy wheel aircraft for use in Antarctica

Type	Wing span, m	Length, m	Altitude, m	Maximum T-O weight , kg	Maximum load, kg	Ferry range, km
IL-18D	37.4	35.9	10.2	64,000	13,500	6,500
IL-76 TD	50.5	46.6	14.8	190,000	50,000	10,580

3. DESCRIPTION OF PROJECT COMPONENTS AND MAIN TYPES OF ACTIVITY

3.1. General provisions

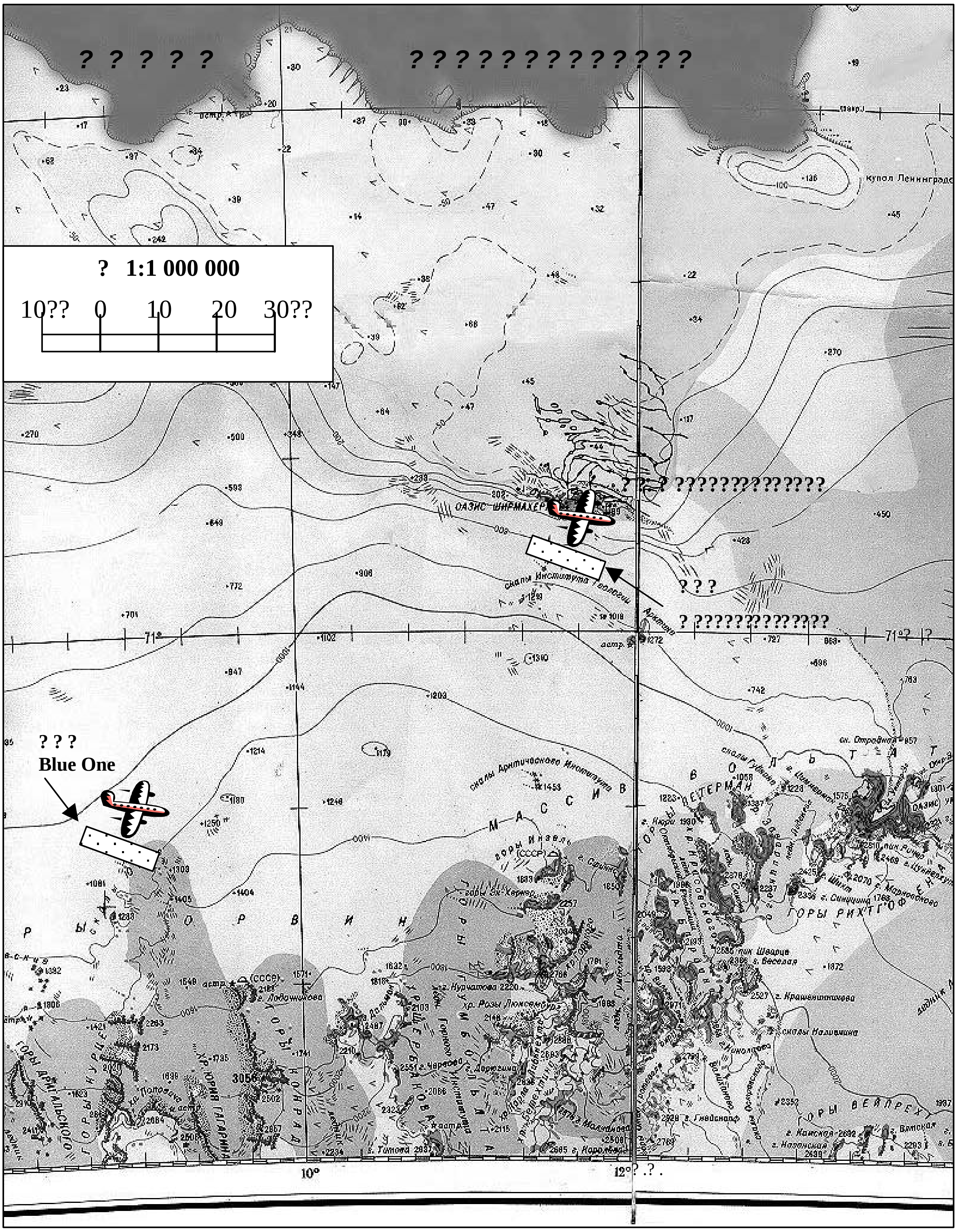
Three major Project components should be considered: snow runway, access road and a field camp with corresponding structures. Their location and main characteristics will be presented below.

The intensity of the proposed construction and methodology of maintenance were in general defined, as they are the most important types of ground activity. Typical scenarios of air operations, their time and quantity are presented below.

3.2. Runway location and main characteristics

The runway site is situated in 10 km to the south of Novolazarevskaya station (Fig. 3.1) on a partly snow-free slope of the ice dome. The surface relief of the runway site is sufficiently level with the surface gradients corresponding to the airfield standards. There are no mounts or any other obstacles in the area either at the takeoff or landing routes.

The distance from the site of ship unloading in Leningradskaya Bay to the runway is about 120 km. The flight time for IL-76 TD from Cape Town to Novolazarevskaya is five hours and a half. The runway location was chosen and delineated on the site in the design documentation of the LENAEROPROJEKT Institute.



???. 3.1 ? ????????? ???? ? ? ? ? ?????????????? ? ? ? ? Blue One

Fig. 3.1. Location of the Novolazarevskaya and the Blue One runways

The geographical coordinates of the airfield control point (ACP – runway center) are as follows: $11^{o}35'44''$ E and $70^{o}50'39''$ S. the true azimuth runway direction is $105^{o}40'$, $285^{o}40'$. The magnetic declination is $27^{o}40'$. The ACP altitude is 550 m a.s.l. The air approaches in the longitudinal direction are open with the surface slopes corresponding to the existing requirements of Russian civil aviation.

The ice runway at Novolazarevskaya station was introduced into operation and included to the Inventory of Russian airfields in December 1981 as an alternate airfield during the flights to Molodezhnaya station. The Novolazarevskaya airfield was used for flights until 1991.

The dimensions of the treated part of the runway comprise 2850 x 90 m with 223750 m^2 of the area of the continental ice surface allotted for the airfield construction.

3.3. Access road

The runway site is in 10 km to the south of Novolazarevskaya station. It is easy to get to the runway by ground-based transport. A safe route about 15 km long was laid from the station in the eastern corner of the Schirmacher Hills along the ice slope to the base camp and the runway.

In winter from March to November, transport traffic by the road is on the snow. The fuel to the runway is delivered from the unloading site in Leningradsky Bay predominantly in winter. During the period of flights, fuel will be delivered to aircraft using refueller that has a sealed double container 7500 liter in volume. In summer, from December to February, the traffic intensity along the road will be minimum for servicing several flights and only passengers and personnel will be delivered.

3.4. Auxiliary structures

In the early 1980s, a temporary field camp was established near the eastern runway margin for its construction and maintenance. The camp combines three houses – a living unit, a power station combined with the repair shop and a radio-navigation station.

All structures are one-storied and are built of wooden panels with foamy stuff. Four people can be accommodated in the camp during the summer season. The power station is equipped with a diesel generator and a shop. The total area of the region, which will be exposed to the impact of the field camp, will be about 400 m^2.

3.5. Requirements for the runway construction and maintenance

To use IL-76 aircraft, the runway with a size of 2850 x 90 m was prepared. The natural surface of bare blue ice was treated according to the technology developed by AARI specialists. The main objective of the technology used was to increase the traction coefficient of the wheel and the runway surface to the values higher than 0.3. The construction technology, which will be applied, includes three main methods for snow treatment:

- snow crushing by a disc-harrow,
- leveling by grader,
- compacting by a multi-wheel road roller.

The technology for runway maintenance includes the same methods of snow treatment although it is less labor consuming. The runway maintenance measures using the aforementioned technology will be repeated during the subsequent summer seasons beginning from 2002. The equipment used for the construction/maintenance of the snow-ice runway at Novolazarevskaya station is enumerated in Table 3.1.

Table 3.1. Equipment used for the runway construction

Name	Mass	External size, length, width and height (mm)	Operating width (mm)	Tire size (mm), (inch)	Pressure in tires (kPa)	Number of psc.
Heavy wheel tractor K-701	12400	7400 2850 3685		28.1 P26	110-170	2
Tractor-bulldozer T170	19850	4960 3600 3180				2
Roller on pneumatic tires DU-39 Net Gross	 6300 25000	5770 2850 2000	2530	370/508 14-20	350-700	2
Sheepsfoot roller	5000	5016 2196 1800	1800			1
Planner	4500		4500			1
Scraper	2500		5400			1

3.6. Time frame

3.6.1. Period of construction. The runway construction will be carried out throughout 2001. The airfield camp will be built in 2001 and up to four people will live there annually during the construction period (about 4 months).

3.6.2. Planned air operations. The planned number of flights at the runway of Novolazarevskaya station in 2001-2005 will be:

- 1-2 flights in November-December
- 2 flights in February-March

3.8. Air operations and aircraft servicing

3.8.1. Types of aircraft. It is planned to use heavy wheel aircraft IL-76 TD and similar types (see Table 2.1 for characteristics) in transport operations.

3.8.2. Flights routes above the airfield area. The main schematic of the trajectories of approach landing and takeoff is presented in Fig. 3.2.

3.8.3. Aircraft refueling. The aviation fuel will be stored in the existing fuel storage of Novolazarevskaya station on the shore of Leningradsky Bay. About 100 tons of aviation kerosene will be delivered annually to the runway. IL-76 will require up to 20 t of fuel for each flight. The refueling operations will be made on the specially prepared site using refueller TZ-7,5.

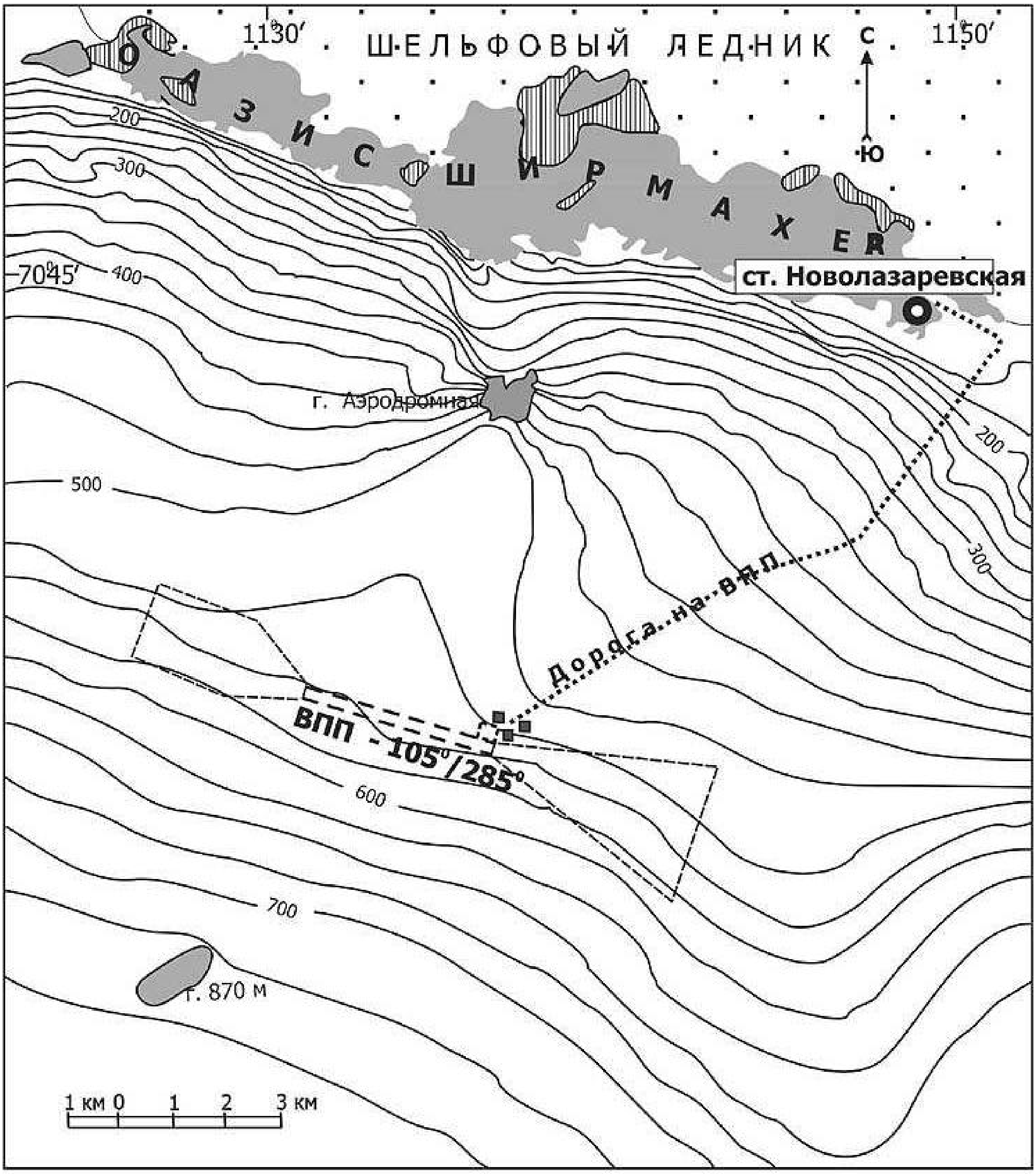


Рис. 2. Схема расположения ВПП ст. Новолазаревская

Fig. 3.2. Layout of the runway location at Novolazarevskaya station

4. CONSIDERATION OF ALTERNATIVES

4.1. Inactivity alternative

The main advantages of this Project for the national programs operating in East Antarctica were formulated above. Introduction of the transcontinental Africa-Antarctica line in interaction with the internal aviation network will increase safety, mitigate the environmental impact and simplify execution of national scientific programs.

Inaction in this issue would present a missed opportunity to improve the existing systems of transportation and safety in East Antarctica. Likewise, the currently existing load on the coastal environment will increase due to increasing number of vessels changing personnel and scientific equipment in the region. The development of intercontinental air network will result in the decrease of sea operations up to their conduct twice a year.

4.2. Alternative variants

4.2.1. Ground runway at the outcrop of mountain rocks. There are no places in the region where the unpaved airfield could be built. The sites of mountain rock outcrops located near the stations have an exclusively hard surface including usually deeply dissected ridges of granitoid rocks.

That is why, the construction and maintenance of runway with gravel pavement on some of these sites, would require significant labor and investments. In addition, the environment and the ecosystems would be also exposed to significant impact. Due to this, this alternative was considered unacceptable and was rejected.

4.2.2. Runway on sea ice. According to a widespread viewpoint, sea ice is a very attractive platform for the runway servicing wheel aircraft. To determine the suitability of sea ice site for the construction of runway, two main criteria are considered: sea ice thickness and snow depth on it. Sea ice should be sufficiently thick to bear the aircraft weight while the snow cover should be moderately thin to remove it. Otherwise, to remove snow from the runway, a large amount of work will be necessary to plough it.

In East Antarctica, most coastal stations were built in the areas where ice breaks up every summer. This natural phenomenon combines well with the traditional system of transportation by sea. On the other hand, there is no site near the existing coastal stations where the first-year sea ice layer is sufficiently thick to withstand heavy wheel aircraft.

The possibility of using a sea ice platform made thicker by pouring seawater was investigated in the areas of Syowa and Molodezhnaya stations in 1985-1988 (Nakawo, 1982). Field experiments show that an artificial ice platform up to 3 m thick could be built by watering. However, in many respects the construction and maintenance of runway on sea ice is not a simple task. To prepare the runway, special technical equipment and methodology are required. For construction, a large quantity of technical equipment such as bulldozers, snowplows, strong water pumps, etc. are needed. In addition, the runway on sea ice can be damaged or completely destroyed by some natural phenomena at any unpredicted moment of time. Given the aforementioned facts, the runway built on sea ice cannot be considered as an acceptable alternative.

4.2.3. Runway on bare ice in the area of Orvin Mountains. Approximately in 90 km to the southwest of the selected runway site, a vast bare ice field called the Blue One exists at Novolazarevskaya station. Landing of aircraft of IL-76 type is possible on this site without the ice surface treatment. Single IL-76 flights were made on Blue One in 1999 and 2000.

However, remoteness of this site from the main infrastructure of Novolazarevskaya station and the onshore fuel storage does not allow its consideration as an alternative of the chosen site in 10 km from the station. The study of the route from the station to Blue One has revealed the presence of dangerous cracked segments on the glacier, which makes the use of the ice runway for the purpose in question unacceptable.

5. DESCRIPTION OF CURRENT ENVIRONMENTAL STATE

Since some factors related to activity planned will impact not only the ice ecosystem in direct proximity to the runway, but also some ecosystem components of the adjoining ice-free areas, a brief characterization of the current environmental state of the adjacent Schirmacher Oasis territory is presented here.

5.1. General physical-geographical characteristics of the study area

The study area is located on the Queen Maude Land (East Antarctica). This is a typical mountainous oasis more than 100 km remote from the seacoast. It presents a segment of mountain rocks outcropping to the surface at the boundary between the continental ice sheet and the Lazarev Ice Shelf. The oasis length is 17 km. It extends in a narrow band up to 3 km wide in the direction from west-northwest to east-southeast. The morphometric characteristics of the Schirmacher Oasis are presented below:

- oasis region (area, km^2) ………… 1000
- total area, km^2 ………………………35
- main massif, km^2…………………….31
- lakes-lagoons and sea bays, km^2 ……..3
- bedrock, km^2…………………………27
- snow fields and inland glaciers, km^2….3
- lakes, km^2……………………………..2
- height, max, m………………………221

5.1.1. Geology and geomorphology. In the geological respect, the Schirmacher Oasis presents a massif comprised of the pre-Cambrian age strata consisting of acid gneiss and crystalline slates with small intrusions of gabbro-norites, gabbro-diorites and numerous veins of pegmatites, more rarely aplites. The territory of the Schirmacher Oasis experienced a long period of continental development. Sedimentary rocks are poorly represented. The morphostructure of the Oasis in the course of its development has undergone significant transformation under the action of exogenous processes, of which the accumulative and scouring activity of the ice sheet and the ice shelf were most active as well as nivation, erosion, frost and eolian weathering. The impact of these processes has lead to the formation of a variety of relief forms.

The oasis relief presents a typical hillocky area with average heights ranging between 130 to 150 m (maximum 221 m).

The territory of the Oasis experienced at least three glaciation phases and the traces of ice cover glaciation are spread over the entire area of the oasis. However, the strike of most oasis troughs is determined by the tectonics and does not coincide with the ice discharge direction. The real scouring troughs are single. The accumulative relief forms of glacial origin in the form of individual hills and ridges are mainly developed in the southern tip of the oasis and as single features over the rest of the territory. Along the northern margin of the Oasis, the ice shelf formed a series of head end ridges and shore moraines.

Loose deposits of non-glacial and mixed origin are more rare. Fluvio-glacial deposits in the form of sand, gravel and more rarely pebble bed in small areas at the bottom of the valleys and in the mouths of ice flows. The thickness of detrital cones comprises 0.5 m At the tops of most cones and ridges and in the upper and middle parts of their slopes (except for steep and precipitous), glacial-eluvial-coluvial placers bed represented as a rule by the same rocks that are encountered in the moraine. The eluvial deposits are mainly developed at very gently sloping and small in size ridges in the eastern part of the Oasis as well as in the form of individual patches at gentle peaks of some ridges. They are represented by fragments of underlying bedrock of different dimensions. Lacustrine-glacial deposits are represented by sands, sandy loam and loam with insignificant quantities of gravel, pebble and boulders. The thickness of lacustrine deposits does not obviously exceed 2-2.5 m. Eolian deposits represented by sands and fine gravel are widespread. Their thickness is usually insignificant – about 10-30 cm (maximum 95 cm). The development of nivation in the territory of the Schirmacher Oasis has lead to occurrence of numerous niches, corries and closed depressions. The erosion relief forms are developed extremely little. Eolian weathering resulted in the formation of quite numerous weathering cells, niches, valleys and scours.

5.1.2. Hydrology. Due to relief features with abundant depressions, small thickness of soft deposits and poor drainage properties of frozen rocks, this small mountainous area has up to 180 lakes of all sizes. Lakes of glacial origin whose basins are formed by scouring dominate. There are many relict lakes-lagoons situated at the boundary between the oasis and the ice shelf. Both shallow (3-5 m) and deep lakes (between 20 to 120 m) are encountered.

Water in the lakes has very low mineralizing and low hardness. The levels of carbonates in most lakes comprise 0.02-0.04%. An inverse thermal stratification, which is characterized by higher temperatures in the near-bottom water layers and low temperatures near the surface, is typical of the lake. Due to a small quantity of precipitation and strong winds, the water bodies are almost devoid of the snow cover and the snow distribution in the basins of the water bodies is extremely non-uniform.

Shallow lakes with rocky shores are completely or partly ice-cleared in summer, whereas the epi-shelf lakes contacting the ice sheet remain under the ice the year-round. At perennially ice-covered lakes, the minimum ice thickness is observed in April while on lakes with a complete or partial breakup – in January-February.

Seasonal changes of water temperature are determined most of all by the radiation regime. A decisive cooling influence is produced by surrounding glaciers and the warming effect – by surrounding rocks. The melt water inflows cool in general the water mass of the lakes.

There are no large rivers in the territory of the mountains. Short watercourses function only during the period of active snow melting.

5.1.3. Glaciology. The Oasis is located at the joint of the continental ice sheet and the ice shelf. North of the station, there is an ice shelf with a weakly undulating surface ending with the Leningradsky ice dome. From the south, the continental ice sheet slope approaches, which reaches a height of 1000 m at a distance of 50 km. Several nunataks elevate above ice at this slope. The ice sheet movement along the slope is complicated both by the ridges of the mountainous belt of the Queen Maude Land and numerous nunataks and the Schirmacher

Oasis. The ice shelf contouring the ice sheet slope foot is represented here by grounded and floating areas. From the side of the Mushketov Graben, a strong ice flow moves towards the Oasis, which probably presents a western branch of a large outlet glacier flowing in this ridge. Its southern boundary near the study area is represented by a lateral moraine almost 30 km long. The ice flow rate in this stream in the "channel line" is close to 1000 m/year and probably more. From the south-southwest streamlining the Oasis from the west, there is another slightly less strong flow. These two streams merge north of the Oasis approximately at meridian $11^{o}30'$ – $11^{o}32'$ E and flow farther north. The glacier advancing to the rocks forms several small sites of broken ice under pressure. The largest of them adjoins the Oasis from the northwest occupying an area of around 18 km^2. Two much less sites (1 and 0.5 km^2) are located at the northern margin of the Oasis in its central and eastern parts. Cracks are often observed on the glaciers. More detailed information is contained in the Annex.

5.2. Climate

Climate of the Oasis with a dominating continental character is formed at low temperatures predominantly by solar radiation intensity with the weather depending on the type of winds that determine the character of clouds and air temperature. The dominating most intense cyclonic easterly and southeasterly winds result in the increase of temperature in winter and its decrease in summer in the Oasis, which is accompanied by significant cloudiness, snow storms, snowfalls and storm winds. The catabatic south-southeasterly wind causes sometimes a sharp air temperature and wind speed difference being combined with clear weather and a decrease of air humidity to 30-40%. Much of the Oasis is characterized by the absence of continuous snow cover not only in summer when strong melting and evaporation are observed, but also in winter when strong southeasterly winds blow away the fallen snow over a considerable area. In the summertime, the surface of the Oasis due to a strong solar energy absorption by the dark surface of rocks and insignificant albedo receives solar heat 3-fold greater than the ambient snow-ice surface. The rock surface of the Oasis is sometimes heated up to 26° ? while the air temperature in the surface layer increases to 5° ? . The relative air humidity is not greater than 50%, on average for a year. Under such conditions, strong evaporation and melting of snow occurs, which is probably, one of the decisive factors ensuring the existence of the Oasis under the current climatic conditions.

The following parameters provide some understanding about climate in the Oasis (from multiyear observations at Novolazarevskaya station).

Direct radiation ($kcal/cm^2$) ……………………..….43.9
Total radiation ($kcal/cm^2$)………………...…...………93.8
Radiation balance ($kcal/cm^2$) ………………….23.9
Absorbed radiation ($kcal/cm^2$) ……...…...……….69
Average annual air temperature .……….……..-11.0°?
Mean annual atmospheric pressure at sea level (mb).. 988.0
Mean annual wind speed (m/s) ……………….……..10.2
Prevailing wind direction …………………… …..ESE;
Mean annual relative air humidity (%)…… ………… ..52
Mean annual absolute air humidity …..…0.07 hPa;
Total cloudiness (points) ……. ……………….…. 5.8
Low cloudiness (points) …………………………………1.0
Annual precipitation (mm) …..........…………………..….. 309
Number of days with snow storm a year……..…………..88

5.3. Lake ecosystems

Lakes of the Oasis belong to ultra-oligotrophic water bodies. Total mineralizing of surface water of lakes in the Schirmacher Oasis is not more than 400 mg/l. There is a clear difference in the sum of ions of water of the southern, central, and northern areas of the Oasis. The least mineralizing of water is observed n the lakes situated in the south of the Oasis – 26.73 and 23.95 mg/l. Mineralizing of water of the lakes in the central area is 46.6 mg/l. most mineralized are Lake Krugloye – 374.87 mg/l and small residual lakes – 144.91 mg/l, 208.13 mg/l and 170.71 mg/l. The Na and Cl ratio indicates a uniform continental genesis of all surface waters.

Distinguishing features in the formation of the regime of nutrients of the water bodies in the Schirmacher Oasis under the natural conditions include their low concentrations in melt waters, very sparse vegetation and soil at the watersheds. The concentration of mineral phosphorus and nitrogen in water of the water bodies of the Oasis is much less than in the other lake regions of the Antarctic (2-8 ug/l P/PO_4, 3-14 ug/l N/NO_3). An insignificant increase of phosphates and nitrates in water of some lakes observed in the late 1990s compared to the 1970s is at the level of natural fluctuations.

The annual value of primary production of phytoplankton is quite low (0.58 gM/m^2 in Lake Verkhneye), which is comparable with the values obtained for the Canadian Arctic lakes. Under the conditions of anthropogenic eutrophication (Lake Glubokoye), the primary production of phytoplankton significantly increases reaching 3.7 gM/m^2. Daylight penetrates to a large depth contributing to the development of bottom algae forming sufficiently thick mats. The total primary production (phytoplankton+phytobenthos) is approximately equal to the annual breathing of lakes.

5.4. Fauna and flora

5.4.1. Flora. Flora of the Oasis similar to the entire East Antarctica is represented only by non-vascular plants: algae, lichen, microscopic fungi and moss. Terrestrial vegetation is represented by individual rare patches of lichen on a rocky substrate and moss concentrations on silt. The vegetation coverage of the Oasis does not exceed several percents.

<u>Algae</u>. Algae were observed practically in all biotopes studied including lakes and their coasts, in the temporary melt watercourses, at soil surface and in the cracks of mineral substrate and at the surface of mosses and snow fields. According to summary data, 95 species of *Cyanophycea*, 2 species of *Chrysophycea*, 54 species of *Bacillariophycea*, 4 *Xanthphyceae*, 1 *Dinophyceae*, 38 *Chlorophyceae* and 14 *Conjugatophyceae* were recorded in the Oasis. It is interesting that in water of freshwater lakes in this area, typical marine diatoms were detected together with different freshwater diatoms in the same region.

<u>Lichens.</u> About 40 species of lichens were detected in the Oasis during the study period. Most common and widespread are *Acarospora gwynnii, A.williamsii, Umbilicaria decussata, Rhizocarpon flavum, Lepraris membranacea, Rinodina olivaceobrunnea, Candelariella halattensis, Umbilicaria aprina.*

<u>Mosses</u>. No systematic studies of bryo-flora were made, although moss is widespread over the Oasis territory. In its distribution, mosses are confined to moistened habitats. According to en-route collections, 7 species of cormophyte mosses from the study area are known. From Lake Glubokoye (from a depth of 32.2 m), an endemic species *Plagiothecium Simon*ovii is described.

5.4.2. Terrestrial invertebrates. No special studies of fauna of terrestrial invertebrates were made in the Schirmacher Oasis. Based on general information on fauna of freely living invertebrates of the continental Antarctica (Rounssevell & Horne, 1986), the following species are obviously encountered in the territory under consideration:

- Acarina
- Tardigrada
- Nematoda
- Protozoa

5.4.3. Birds. The avi-fauna of the region is poor in respect of species, the population of birds being not numerous. Only 4 species were recorded in the Oasis territory.

<u>Adelie Penguin (*Pygoscellis adeliae*).</u> In spite of remoteness from the seacoast, the Oasis of the territory is constantly visited by Adelie penguins from the 1980s. A small number of birds (around a dozen of pairs) undertakes unsuccessful efforts of breeding in the station area in the old dump of construction and domestic garbage.

<u>South Polar Skua (*Catharacta maccormicki*).</u> It is the most noticeable bird of the area, since this is the only open-nesting species of the Oasis, which does not avoid contact with man. Up to 30 skuas inhabit the Oasis. Around 11 nesting sites were recorded although the numbers of nesting birds varied from year-to-year and not all pairs bred every year. Skuas actively consume food wastes at the stations.

<u>Snow Petrel (*Pagodroma nivea*).</u> It is constantly observed in the Oasis in small numbers, nesting is supposed but is not documented.

<u>Wilson's Storm Petrel (*Oceanites oceanicus*)</u> is not a numerous nesting species in the Oasis.

5.4.4. Mammals. At present, no mammals are encountered in the Oasis, although mummified corpses of seals are noted in its territory and in the vicinity.

5.5. Existing anthropogenic environmental impact in the Schirmacher Oasis area

At the present time, two wintering stations operate in the Schirmacher Oasis:

- Novolazarevskaya (Russia) from 1961;
- Maitri (India) from 1989.

In order to gain some understanding of the character and extent of anthropogenic transformations in the region, we shall present the characteristics of the environmental loads due to activity of the Russian Novolazarevskaya station.

5.5.1. Characteristics of anthropogenic environmental impact of Novolazarevskaya station

The station is located at the extreme southeastern tip of the Schirmacher Oasis (70°46'S, 11°50'E, 15.8 m a.s.l) in approximately 80 km from the Lazarev Sea shore. At present, the infrastructure of Novolazarevskaya station includes:

- structures of the old Novolazarevskaya station;
- current Novolazarevskaya station;
- tank farm on the Lazarev Sea shore;
- field base of the airfield (in 12.5 km to the southwest of the station at the ice sheet slope).

Initially from 1961, the Novolazarevskaya station was located on the shore of Lake Stantsionnoye. During the period of its operation, the environment of the area was significantly transformed. The greatest impact was produced on the ground and water systems. Thus, a dump was organized on multiyear ice of Lake Glubokoye. Later, the ice has melted and waste submerged to the lake bottom. The coastal band of Lake Stantsionnoye is also polluted. It was caused by the overflow of the fuel tank of the station tank farm and its significant leak to the lake (approximately in 1973).

In 1977, preparation for the station construction at the new place began. All facilities of the new station are combined by wooden foot-plankings with guard railing. Heating of buildings is by radiators that are supplied with energy from the diesel-electric station. In some premises, oil radiators are set up. Ventilation is mainly natural.

The constantly acting environmental impact sources include ground transport vehicles, diesel-electric station and station structures. Episodic sources are accidental fuel spills and leakage and wastes from servicing the equipment and other kind of work.

Practically all buildings of the old station constructed almost 40 years ago during the period of its creation (1961-1962) were dismantled in 1994-1995 and transported from the Antarctic while the territory around the station was cleaned from garbage.

Transport vehicles and their servicing

Chemical pollution. The average fuel consumption relative to the conditions of Antarctica for different transportation vehicles comprises for MI-8=600 l/h and for GTS=0.7 l/km. The main pollutants ejected with the fuel combustion products and their volumes during the average daily operation time at the field base are presented in the Table.

Table

Mean daily emission of pollutants during operation of different transport vehicles at the Antarctic field bases

Pollutants	Emission volume, kg/day	
	GTS	MI-8
Aldehyde and organic acids	0.019	0.164
Hydrocarbons	0.44	3.90
Nitrogen oxides	0.27	2.37
Carbon oxide	5.14	45.80

The Novolazarevskaya station has two tank farms at the barrier of the Lazarev Sea (in 80 km to the south of the station. There are 16 tanks of 50 m^3 and 7 tanks of 20 m^3 each. During the period of operation of the 37th RAE, complete cleanout of all 16 tanks PC-50 was performed. Two tanks of 50 m^3 each are used for diesel fuel supply of DES with the third tank (not connected with the pipeline) being a reserve one. The reservoir of 20 m^3 is intended for refueling transport vehicles with diesel fuel. The reservoir of 25 m^3 is mounted on the ATT chassis. The aviation fuel is stored at the airfield.

The diesel-electric station and transport vehicles are the main consumers of combustive-lubricating materials. Over the period March-December 1993, the consumption of fuel-lubricants at DES of Novolazarevskaya station was 221 t of diesel fuel and 9.2 t of oil.

The repeated fuel transfers and transportation of combustive-lubricating materials by a complicated route have contributed to numerous local spills of oil products and oils. The water system of Lake Prilednikovoye - Lake Stantsionnoye - Lagerny Bay with the watercourses connecting them has been subjected to pollution to the greatest extent. The main reason is the accidental fuel spill to Lake Stantsionnoye (about 5 t). In addition, solar oil from the DES situated in 70 m from the shore and wastewater from the galley and the bath- and laundry-house were getting to the lake. As a result of the station activity, the chemistry of water flowing out of Lake Prilednikovoye after passing the regions exposed to a strong anthropogenic impact has significantly changed. The concentrations of iron, zinc, nickel and copper have increased 10-100-fold as well as those of fuel-accompanying metals – lead, cadmium and cobalt (up to 10-fold).

The most unfavorable land area in the vicinity of Novolazarevskaya station is the old station area including the territories adjoining Lake Stantsionnoye, especially the territory of open storage of technical vehicles and materials, and the area near the tanks with fuel-lubricants. The soil surface area in these places contains a significant (visually observed) quantity of oil products and has a typical odor.

The analysis of water from the lakes located outside the direct station impact limits for heavy metals has revealed their sufficiently low concentrations. No oil products were detected in the shore area of Lake Pomornikov and the distant shore of Lake Stantsionnoye (near the old station).

<u>Technical garbage and waste.</u> Over the period of operation of many expeditions, a large quantity of metal scrap and oil drums has been accumulated at the station and in the airfield territory and on rock outcrops near the former East Germany station Georg Foster. In 1990, the total quantity of metal scrap comprised more than 200 t. In 1994-1995, a complex of nature protection measures were undertaken jointly with the German Antarctic Expedition to liquidate the infrastructure of the old Novolazarevskaya station and the German Georg Foster Base, remove the dumpsites and clean up the adjoining territory from garbage. Waste with a total weight of more than 500 t was taken out to Cape Town (South Africa).

<u>Mechanical disturbance</u>. The surface soil layer over a large area of the station has undergone mechanical transformation during the time of its existence due to the motion of caterpillar transport causing strong dusting of the station, especially during helicopter operations. The total mileage of all kinds of transport for supporting station activity was more than 5000 km in 1992 (including the approaches to the ice shelf barrier). The artificial landscape transformation is insignificant except for a specially planned parking place for auto transport.

<u>Life activity of the station</u>

<u>Domestic waste</u>. In different years, between 12 to 56 people wintered over at the Novolazarevskaya station. During seasonal operations, this figure increased to 60-70 people (together with the air team). For the last few years, the numbers are up to 30 people.

Calculations have shown that at an average number of polar explorers of 17 people and the area of Lake Glubokoye of 134, 000 m^2, it receives on average for a year, 2.1 g of total nitrogen and 0.26 g of total phosphorus per 1 m^2. Direct observations indicate that in summer of 1976-1977, 1.14 g of mineral nitrogen and 0.30 g of mineral phosphorus were discharged to 1 m^2 of the lake surface with domestic and sewage water. With clean melt water, the lake received 0.17 g of mineral nitrogen per 1 m^2. No discharges of mineral phosphorus were observed.

The main source of sewage water is a bath-laundry house and a mess-room (galley), lavatory, DES and houses of aerologists. The total mean daily sewage water volume is more than 450 l.

Sewage water is pumped out directly to the ground. In winter, these wastes freeze and are exposed to natural weathering while in summer, they flow down the slope towards Lake Glubokoye together with melt water. No treatment of sewage water is made at the station.

Fecal wastes from the living houses were transported and dumped to a ravine in 2 km from the station between the heights with 136 and 125 m marks. At the present time, most of domestic and fecal waste is dumped to the ice shelf crack, which moves directly to sea.

Domestic garbage mainly presents a tare from food products – tin and cardboard, bottles and cans, etc. The burnable refuse is burned in a closed stove. Glass tare is stored at a special site. Food wastes are collected to a special container set up near the galley and then taken away and dumped to the ice shelf crack.

Waste from research studies. Chemical waste includes waste of gas generation at the upper-air sounding pavilion. Until 1987, the remains of hydrogen generation reaction containing caustic soda were dumped beneath the upper-air sounding pavilion on the shore of Lake Glubokoye. These wastes with melt water were getting to the lake. From 1987, the wastes were collected to empty drums and transported to the dumpsite. In 1992, the upper-air sounding at the station was interrupted. At present, the upper-sounding program is resumed. The wastes are stored in the metal drums. Another source of chemical wastes was the Geophysical service, which produced several hundreds of liters of photo solutions a year. From used solutions, silver was extracted by a chemical method to export back to Russia, while the remaining portion was poured to the ground. At present, the wastes are disposed to the ice shelf crack.

Radiation situation. The review measurements of the strength equivalent to the exposure dose of the locality have not caused any doubts in the relative radiation safety of the area.

Bacterial component of the anthropogenic influence on natural media. An assessment of bacterial semination of Novolazarevskaya station and the adjoining territory has revealed a sufficiently wide range of variations of the calculated characteristics obtained at different sites. Thus, by the index of saprophyte bacteria quantity, the differences between the minimum and maximum values were more than 4 orders of magnitude. The index of the total microbial number also varies over a wide range from 1.9 thousand to 25 millions of microbial bodies. On the sites exposed to biological contamination, the dominance of mesophyll bacteria over psychrophilic organisms was more often observed and vice versa, in places where the technogenic and other types of anthropogenic influence are more pronounced, the increase in the numbers of psychrophilic microflora was recorded. In the polluted areas, the replacement of natural microflora and the existing microbiocenosis by allochthonous microflora and alien biocenosis is traced.

It follows from the above said that the territory of the Oasis has been for a long time in the zone of a constant anthropogenic impact and according to the classification proposed by Russia at the ATCM XXIII, part of the Oasis where the station infrastructure is located, can be classified as a non-recoverable area (NRA). Thus, the impact of the activity, which by its scale is in the framework of current activity in this area, will be within the limits of impacts produced by the current station activity.

6. ENVIRONMENTAL IMPACT

6.1. Possible impact factors related to the proposed activity

A complex of air and airfield operations includes the types of activity that interact directly or indirectly with the environment. In each case, a potential impact on the environment can be revealed from occasional relations between the nature of the given activity and the biophysical attributes of the environment. The specific types of activity in the Schirmacher Oasis and the corresponding factors of environmental impact are enumerated in Table 6.1.

Table 6.1. Types of activity and related environmental impact factors

Types of activity	Impact factors	
	Construction period	Operation period
Aircraft Airplane in operation (generation of energy) Airplane servicing - refueling - Deicing treatment	No No	- Noise - Exhaust gases (NOx, SOx, CO_2, heavy metals, other combustion products) - Fuel leakage, deicer leaks.
Runway Construction and maintenance of the compacted snow runway Transport traffic by the road	- snow compacting - introduction of alien elements to the landscape (landmarks, etc.) - Exhaust gases (NOx, SOx, CO_2, heavy metals, other combustion products) - Noise - Mechanical substrate disturbance	- snow compacting - introduction of alien elements to the landscape (landmarks, etc.) - Exhaust gases (NOx, SOx, CO_2, heavy metals, other combustion products) - Noise - Mechanical substrate disturbance
Ground support Organization of the field camp Generation of energy	- introduction of alien elements to the landscape - noise - exhaust gases (NOx,	- introduction of alien elements to the landscape - noise - exhaust gases (NOx,

Life activity	SOx, CO_2, heavy metals, other combustion products) - domestic waste - biological contamination	SOx, CO_2, heavy metals, other combustion products) - domestic waste - biological contamination
Radio-navigation support	No	- electrical-magnetic emission
Fuel storage and handling	- fuel leaks	- fuel leaks

6.2. Materials and methods

The methods applied in the previous EIA both for the Arctic and the Antarctic were used to assess the environmental impact level of activity related to construction of airstrip of compacted snow with the subsequent air operations. The important documents were considered including materials prepared by Gendrin & Giuliani 91994) as well as by Shears (1995).

In this IEE in order to determine the predictable runway impact, we shall use the approach similar to that used in the abovementioned documents. To analyze the impact of different sources on different environmental components, a method of modified matrices was used. For each type of the established impact, the extent of impact relative to the specific environmental component was determined. The criteria for a semi-quantitative assessment of the impact level are presented in Table 6.2.

Table 6.2. Criteria for an assessment of the environmental impact related to construction of compacted snow airstrip in the area

	Impact	Environmental impact parameters
0	Absent or negligible	Absence of impact or impact cannot be established
L	Low impact	Low impact restricted in space (construction site or local limits) and time (occurring during the time period smaller than or equal to as compared with the recovery of resources or values; or the recovery of resources or values after the end of activity impact will take approximately one generation)
M	Moderate impact	Impact that has a moderate perturbation, which can be statistically revealed; or a short- or medium-term regional scale impact (extending over the entire Larsemann Hills territory) or a long-term low impact within the construction site limits)
H	High impact	Impact with a high perturbation level, objects exposed to

		the impact are not subject to reconstruction, or a long-term or moderate impact beyond the construction site limits

Different environmental impact categories are arranged in the matrix on the basis of their significance. These estimates are based on the currently available general scientific and technical knowledge as well as on the use of the results of special nature protection studies. The matrix is presented in the form of Table 6.2.

Table 6.2. Matrix**.** Environmental impact related to construction of the ice runway and subsequent air operations in the Schirmacher Oasis area

Construction period											
Activity/types of impact	**Medium subjected to impact**										
	Abiotic component				**Biota**				**Values common to all mankind**		
	Air	Snow and ice	Ground and soil	Lakes	Vegetation	Invertebrates	Birds	Microbial community	Wilderness landscapes	Man health	Science
Construction of airstrip											
Snow compacting	0	L	0	0	0	0	?	0	0	0	L
Airstrip marking	0	0	0	0	0	0	0	0	L	0	0
Exhaust gas emission	L	L	0	0	0	0	0	0	0	0	L
Noise	0	0	0	0	0	0	0	0	0	0	0
Field camp deployment											
Installation of structures and equipment	0	0	0	0	0	0	0	0	L	0	L
Exhaust gas emission	L	L/0	L	L	L/0	0	0	L	0	0	0
Waste	0	L/0	0	L/0	0	L/0	L	L	L/0	L/0	L/0
Noise	0	0	0	0	0	0	L/0	0	0	0	0
Biological contamination	0	0	0	L/0	0	0	L	L	0	L/0	L/0
Mechanical disturbance	0	L	L/0	0	L/0	0	0	0	L/0	0	L/0
Transport traffic by the access road											
Exhaust gas emission	L	L/0	L	L	L/0	0	0	L	0	0	0
Mechanical disturbance	0	L	L	L/0	L/0	L/0	0	0	L/0	0	L/0
Noise	0	0	0	0	0	0	L/0	0	0	0	0
Operation period											
Technical maintenance of airstrip											
Snow compacting	?	L	0	0	0	0	0	0	0	0	L
Runway marking	0	L/0	0	0	0	0	0	0	0	0	0

Exhaust gas emission	L	L	0	0	0	0	0	0	0	0	L
Noise	0	0	0	0	0	0	0	0	0	0	0
Support of air operations/servicing personnel											
Allocation of the plot and its marking	0	0	0	0	0	0	0	0	L	0	0
Exhaust gas emission	L/0	L	L/0	L/0	L/0	L/0	0	L/0	L/0	L/0	0
Wastes	0	L/0	0	0	0	0	L/0	L/0	L/0	L/0	0
Noise	0	0	0	0	0	0	L/0	0	L	0	0
Biological contamination	0	0	0	L/0	0	0	L/0	L	0	L	L
Mechanical disturbance	0	0	L	0	L	0	0	0	L	0	0
Electromagnetic emission	0	0	0	0	0	0	0	0	0	L/0	0
Transport traffic by the access road											
Exhaust gas emission	L	L/0	L	L	L/0	0	0	L	0	0	0
Mechanical disturbance	0	L	L	L/0	L/0	L/0	0	0	L/0	0	L/0
Noise	0	0	0	0	0	0	L/0	0	0	0	0
Fuel storage and handling											
Leaks of fuel-lubricants	0	L/0	L	0	0	0	0	L	L	0	0

6.3. Impact on the abiotic component

6.3.1. Atmosphere. The process of construction will contaminate air as a result of operation of vehicles treating snow on the airstrip site. The emission of diesel fuel in the field camp also presents a direct impact on the atmosphere during the restricted period of camp operation. Gases will quickly dissipate and transferred by the prevailing southeasterly winds to the area of the ice shelf of Leningradsky Bay, whereas aerosols and particles will be distributed around the pollution source or deposit on the surface depending on weather. Given a small power of the diesel-generator and a restricted time of machine operation, the impact of exhaust gases on the atmosphere will be local and transitory.

The operation of heavy aircraft increases air pollution with exhaust gases. The exhaust gases include carbon dioxide, nitrogen oxide, sulfur oxide and particulate matter. The gases will however quickly disperse in the upper atmospheric layers due to large heights in which aircraft operate. Moreover, with the use of such aircraft, RAE will reduce the total number of flight hours in the Schirmacher Oasis area since the introduction of heavy aircraft to the RAE logistics will reduce the required number of flight hours for helicopter operations, which are now the main transportation vehicle used in the area. For example, IL-76 can deliver a 40 kg freight from Cape Town (South Africa) to Novolazarevskaya by one flight. The flight time at low altitude in the area will make less than one hour while to deliver the same freight by helicopter in case of ship-shore unloading operations will require 20 flight hours. Thus, the use of heavy aircraft will diminish the environmental impact of the RAE logistics operations.

6.3.2. Snow and ice. At the runway construction site, a segment of natural snow with an area of 223750 m^2 covering the ice sheet will be subjected to impact. The procedure of construction and maintenance presents three main types of snow treatment: grinding, rolling and compacting. However, the only result of impact on snow during the construction and maintenance is its temporary compacting. The total thickness of the compacted snow layer within the runway will be approximately 1.0 m a year after the beginning of construction. During the subsequent years of airstrip maintenance, the thickness of the upper compacted snow layer will increase in the process of natural snow accumulation. The increased snow density at the runway site will result in insignificant changes in the process of its natural change.

Particulate matter and aerosol particles from the composition of exhaust gases of different sources (ground transport, aircraft, diesel-generator) will spread and deposit on the snow surface around the contamination sources at a different distance depending on the meteorological conditions.

Local impact due to small fuel leakages will occur on the runway site and along the access road. The main source of leakages is vehicles, fuel tanks and pipelines. Small fuel leaks can contaminate soil, ground and snowdrifts along the access road and the airfield camp area. This will cause increased melting resulting then in small changes in the local seasonal drainage system of melt water. Snow contamination with fuel on the runway can be due to small spills during refueling of vehicles and aircraft. However, strict observance of the requirements for handling oil products and well-arranged maintenance will make these leaks minimum.

6.3.3. Ground and soil. In the field camp territory at the site where the fuel tanks are located, there will be a local impact due to small fuel leaks. The main source of fuel leaks is fuel tanks and pipelines. Small fuel leaks and polluted melt waters at the site of fuel tanks and the airfield camp can contaminate soil. However, a well-organized procedure for refueling and the use of transport in good order will make these leaks minimum.

Deposition of aerosol particles of exhaust gases containing soot and heavy metals can be another source of ground and soil contamination. Given a low intensity of traffic, the prevailing wind direction and a low diesel-generator capacity, the contamination from deposition of exhaust gases will be less than a minor.

The transport traffic along the road during the warm time of the year can lead to various mechanical disturbances of the substrate connected with ground displacement and disturbance of its mechanical structure. To avoid this, the transport traffic is planned for the colder time of the year on the snow cover. In the event of the need for transport motion on the ground cover, a number of measures should be observed to minimize damage.

6.3.4. Lakes. Insignificant contamination of the water bodies can occur due to deposition at their surface of aerosol of exhaust gases containing soot and heavy metals and due to melt water of snow contaminated with aerosol. Taking into account low traffic intensity and a low diesel-generator capacity, the contamination from deposition of exhaust gases can be considered transitory and local. Well-organized operations with fuel and the use of transport in order will make the minimum impact on the water bodies.

6.4. Impact on biota

6.4.1. Hydrobionts (see Lakes). A short period of activity and its remoteness cannot cause toxic effects and increase the mortality of hydrobionts.

6.4.2. Vegetation. As is known, lichen and moss are good accumulators of some pollutants spreading in the air and to a lesser extent in the water media. The depositing soot and dust disturb the processes of photosynthesis and breathing of plants. Mosses and lichens growing along the road and in the leeward zone from the exhaust gas sources will be exposed to contamination to the greatest extent. Of pollutants, heavy metals will be the first to accumulate. Most sensitive to contamination are bushy and leaf-like forms of lichens. Given a low intensity of the planned transport activity, the impact of chemical contamination will be negligible.

The Antarctic vegetation, especially lichens, is distinguished by exceptionally low growth rates, which determines their increased vulnerability to mechanical damage. Since terrestrial vegetation in the Oasis is spread in rare spots, it is necessary to choose the traffic routes not affecting the moss-lichen tussocks.

To prevent damage, the main traffic flow is planned for the colder time of the year on the snow cover. In case of the need for transport to move on the ground cover, the well-worn road should be used. When moving on foot, it is necessary to avoid segments with developed vegetation.

At observance of the aforementioned rules, the impact due to mechanical disturbance is expected to be minor or transitory and of a site character.

6.4.3. Invertebrates. Contamination of soil-ground and vegetation turf can lead to contamination of invertebrates inhabiting them and accumulation of pollutants in their organisms, which may result in insignificant toxic effects. However, given the restricted contamination scales, the damage to terrestrial invertebrates can be considered of a site character and minor.

6.4.4. Birds. In the direct proximity to the proposed runway locality and the airfield camp, there are no colonies of birds. Low intensity of the flights planned and remoteness of the runway from the nesting grounds of birds allows a conclusion about the transitory and minor impact. The noise from the transport motion by the access road will be an insignificant anxiety source for several pairs of skuas nesting in the vicinity (Fig. 3.2). However, taking into account the low level of activity planned, the impact of noise on birds can be considered of a site character and minor.

6.4.5. Microbial communities. Presence of man and his activity in the new areas results in the biological contamination with alien bacteria.

Given a restricted scale of the increased presence of man in the Oasis and sufficiently low indicators of the ongoing spreading of alien microflora, his impact can be considered as long-term by time, but restricted by spreading and minimum by the level of disturbance.

An accidental contamination of soil, vegetation and water bodies can result in the change of habitat conditions for microorganisms and their nutrition sources and hence cause changes in the structure of the community, viability of microorganisms and disturb the process of organic matter exchange.

Well-organized operations with fuel and the use of transport in good order will make fuel leakages and contamination with exhaust gases minimum, i.e. not capable to influence the micro-biota.

6.5. Impact on human values

6.5.1. Wilderness landscapes. Considering that the main activity will be undertaken in the non-recoverable (irreversibly transformed) area (NRA) while the runway construction is planned at the same place where old airfield structures were located, the impact on wilderness landscapes (their visual and acoustic media) will be not more than minor. However, with the aim of minimization, attention should be devoted to planning the location of structures and technical vehicles taking care of their external look as well.

6.5.2. Human health. Construction of the new airstrip will enhance man safety in case of emergency evacuation (See also Microbial communities).

6.5.3. Science. The possibilities of scientific studies in the Schirmacher Oasis area will improve significantly with the use of aviation. Introduction of aviation will help to organize the early beginning of the scientific season, increase scientific production by reducing the time of shipping to the Antarctic and back and also use the possibility of delivering lead scientists to the field study areas and improve the quality and efficiency of the National Antarctic Programs.

6.6. Cumulative impact

The cumulative impact is determined as a result of superimposed impact from the activity under consideration onto the impact of the activity, which is being implemented in the same area. It is noted that the areas under consideration of Novolazarevskaya station, access road to the runway and the runway area itself are the areas of constant logistics activity of RAE, i.e. irreversibly transformed areas (NRA).

6.6.1. Increase of personnel at Novolazarevskaya station. The construction of snow runway will lead to increased man activity at Novolazarevskaya station and in its vicinity, especially during the summer season. As a result of the increased numbers of personnel, the quantity of produced waste will increase. However, all fuel and dangerous wastes will be removed outside the Antarctic. When the airstrip is in operation, the quantity of wastes to be disposed will probably, increase by 20% compared to the present level. In 2002, a pyrolysis type incinerator will be introduced into practice, ensuring burning of wastes in accordance with the ecological safety standards. The activity in the NRA will be effected in strict compliance with the plan of the area management and the increase of waste will not lead to a qualitative change of the environmental impact level.

6.6.2. Organization of the airfield camp. Insignificant cumulative impact will occur in connection with the resumed work of a small field camp for the support of construction and maintenance of runway located nearby. The camp consists of three houses: living house, power station combined with the repair shop and radio-navigation station. The total area subjected to the impact due to the field camp organization will be approximately 400 m^2. In the base area, the breeding grounds of birds are absent.

7. MEASURES TO MITIGATE THE ADVERSE IMPACT

7.1. Planning of work

The RAE has set up a Working Group to reconstruct the runway activity, its main objective being the development of nature protection rules for activity in the Schirmacher Oasis.

The RAE Main Ecologist is a member of this Working Group being responsible for a clear inclusion to the Plan of Measures of the provisions of the Protocol on Environmental Protection to the Antarctic Treaty.

7.2. Nature protection training

Before a new personnel is dispatched to the Antarctic, RAE acquaints it with the nature protection measures including the runway builders. All Expedition members receive a copy of the Rules of behavior for visitors in the Antarctic of the Antarctic Treaty.

7.3. Organization of waste utilization

All wastes from the activity of the field camp and the runway will be taken away to Novolazarevskaya station.

7.4. Handling of fuel-lubricants

The risk of fuel spill is small and will decrease in the future with introduction of special precaution measures at the places of work with fuel.

7.5. Determination of inevitable impact

The following types of impact connected with the construction of runway from compacted snow and its further operation are considered inevitable:

- snow compacting
- short-term gas exhaust from aircraft, ground transport and generator of the field camp
- short-term noise caused by running aircraft and transport traffic by the access road
- short-term emission of electro-magnetic waves

- local disturbance of the surface caused by transport traffic
- local disturbance of the surface due to people movement
- local damage from the organization of the field camp
- constant insignificant damage to visual medium of natural landscape due to setting up the marks on the runway (runway maintenance);
- periodical damage to visual and acoustic medium of the natural landscape for the period of transport operations in the zone of runway activity (runway maintenance);
- temporary damage to visual and acoustic medium of the natural landscape from the presence and activity of the field camp facilities and vehicles for the period of airfield construction.

The observance of rules and instructions will allow reducing the level of the aforementioned types of impact to the minimum.

8. NATURE PROTECTION MONITORING

The program of monitoring is necessary to define and assess any expected or unexpected impact from the proposed activity. It would be difficult to carry out an extensive environmental monitoring program due to the absence of basic information on many important environmental components and the long-term previous impact of other sources. With this aim, observations on the assessment of current environmental state of the area were undertaken in 2001-2002 in the area of the forthcoming activity. Their results will serve as a basis of nature protection monitoring program of the Schirmacher Oasis.

9. CONCLUSION

The present Initial Environmental Evaluation indicates that the construction and use of the compacted snow runway conducted predominantly in *the non-recoverable area* will have ***not more than a minor or transitory impact*** on the Antarctic environment on condition of undertaking measures to mitigate the adverse impact.

Based on this, it is concluded that the declared activity can be carried out without the Comprehensive Environmental Evaluation (CEE).

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ANNEX

Glaciology of the runway site

Flow rate and direction of glaciers in the area of Novolazarevskaya station

The area of the Novolazarevskaya station is located at the joint of the continental ice sheet and the ice shelf. The continental ice sheet flow along the slope is complicated both by mountain belt ranges of the Queen Maud Land extending in the general latitudinal direction in 100 km southward and by numerous nunataks and the Schirmacher Oasis occupying an area of around 35 km^2 and elongating across the slope. The ice shelf contouring the foot of the continental ice sheet slope is represented here by grounded and floating segments.

From the side of the Mushketov Graben, a strong ice flow moves towards the station area, which probably presents a western branch of a large outlet glacier flowing in this ridge. Its southern boundary near the Schirmacher Oasis is represented by a lateral moraine, which is clearly seen at the ice surface and can be traced over a distance almost 30 km long. The ice flow rate in this stream westward gradually decreases. According to instrumental measurements, the northward ice stream in the Mushketov Graben is more powerful compared to previous information. Significant rates of its branches and peripheral parts (more than 320 m/year in 25 km to the east of Novolazarevskaya station and about 570 m/year near Lazarev station) suggest that the flow rate of its "channel line" is close to 1000 m/year and probably more. From the south-southwest streamlining the Oasis from the west, there is another stream slightly less strong since its alimentation is due only to the ice breaking from the Wegener Plateau through inter-ridge depressions of the mountain belt of the Queen Maud Land. These two streams merge north of the Oasis approximately at meridian $11^o30'$ – $11^o32'$ E and flow farther north (with a small western component). The contact line is well traced along the longitudinal striation. Near the Schirmacher Oasis at the confluence of these flows, there is a site of broken ice under pressure with an area of about 18 km^2. According to data of the magnetic survey conducted in 1962 by N.K. Dmitriyev and A. Kochi, a strong magnetic anomaly was recorded in 7-11 km to the north of the western part of the Oasis, which indicates that bedrocks here are located deep (several meters below the ocean level) and hence the ice shelf is afloat. Since the resistance to motion of the ice shelf from the underlying medium is minimum, the most favorable conditions for merging of two flows and the change of the flow direction of the glaciers were created here. The ice sinking along the continental slope between these two streams moves slowly. South of the Oasis, its rate decreases to 1-3 m a year. Its thickness here is unlikely to be large, and the annual ice inflow to the northern boundary of the rocky hillocky area is probably balanced by ablation. East of the Oasis it is headed by a thick glacier flowing westward and its pressure is sufficient only for a slight curvature of the southern boundary of this glacier. Not far from the moraine – the boundary of this strong flow, one can observe the occurrence of head anticlines. The closer to the moraine, the greater is the influence of the western component on the flow direction of this glacier. To the north of the Schirmacher Oasis, the flow direction is already southwestward. The ice sheet moving to the rocks forms several small sites of broken ice under pressure. Here, its increased ablation occurs due to intense thermal impact of the precipitous northern slopes of he Oasis. Such motion of the glaciers, and in particular, streamlining of the Schirmacher Oasis territory from two sides by strong ice flows due to the bedrock relief features in this area is one of the main causes of its occurrence and existence[3].

Relief features

The largest site of broken ice under pressure adjoins the Schirmacher Oasis from the northwest occupying an area of around 18 km^2. Two much less sites (1 and 0.5 km^2) are located at the northern margin of the Oasis in its central and eastern parts. The formation of broken ice is related to the latitudinal motion of the ice shelf directed westward in the eastern part of the Oasis (with a significant southern component near the bedrock outcrops) and eastward in the western area. At the place of these two streams merging, the monolith glacier begins to break into separate blocks reaching more than 15-20 m in the cross size that are pushed upwards and creep onto each other. As a result, a conglomeration of ice blocks forms. It is chaotic, but sometimes the ridges of hills extend parallel to the Oasis coastline. At the time of autumn-winter snowfalls and winds, blown snow piles up extending to the west-northwest. In summer, melting begins at the steep slopes of the northern exposition. Here, selective melting is pronounced.

Under the favorable conditions, deflation troughs occur from the west-northwest side of the ice blocks on the head broken ice. Their size is comparatively small here. They reach much greater size near the nunataks where several of them, but more often by 2 from the northern or northwestern side form. Their depth is 20-25 m, the length is up to 500 m and the width is 60-70 m. Such troughs were observed near the Palets and Bazisny nunataks and one – near the Aerodromny nunatak.

Where the ice shelf segments flowing with a different rate contact, longitudinal tectonic striation forms. It is typically represented by a series of parallel or almost parallel bands elongated in the glacier flow direction whose length reaches several kilometers. North of the Oasis where two ice streams streamlining it merge and continue their flow northward, the external look of striation is different. These are several parallel bands 1-1.5 m wide extending at a distance of 10-130 m from each other.

Ogives that are poorly visible from the glacier surface are clearly seen from the air. They are widespread in the area 3-10 km to the west from the north of the western tip of the Schirmacher Oasis. Their shape is falciform with the distance between them comprising 100-110 m.

Cracks are often observed on the glaciers. The dynamic cracks are most widespread. One should distinguish lateral cracks forming as a result of different rates of the axial and lateral parts of the ice flow or at streamlining of nunataks. Such cracks can be seen in 2-4 km westward of the western tip of the Schirmacher Oasis (along the lateral part of the ice flow streamlining the Oasis) as well as around the Aerodromny, Bazisny and other nunataks. The shape of the cracks is falciform or curvilinear; the length is 10-30 m while the width in the middle comprises 1-2 m and sometimes 3 m. There are cracks on these segments and transport motion is difficult and often dangerous.

The second type is transverse cracks that are usually confined to a convex bend of the ice slope. They are represented by a series of quasi-parallel cracks of significant length between several tens to several hundreds of meters and sometimes several kilometers. Their frequency and width depend on the glacier flow rate. To the south of the Schirmacher Oasis where the glacier flow rate is not greater than 10 m/year, there are no cracks at all. In one kilometer to the east where the rate is 15-20 m/year, the cracks are few and their width is not more than 5-10 cm. In 20-25 km to the east of the Oasis where the ice sheet moves with a rate of 250-300 m/year, its surface is broken with numerous cracks up to one meter wide. In 7-8 km to the southwest of the western tip of the Oasis where the rate is quite significant and the longitudinal profile bend is especially steep, the cracks are so numerous and wide, that a real icefall occurred here[3]. The transverse cracks on the glacial surface are usually located perpendicular to the direction of its motion. The boundary of the grounded segments of ice shelf is determined most precisely by the coastal cracks. In the vicinity of Novolazarevskaya station, these cracks were detected in two places: near the foot of the southern slope of Leningradsky Dome and in 2-3 km to the north of the eastern tip of the Schirmacher Oasis.

Their width is 2-3 cm and the length is very large. It is necessary to say that the cracks located in the ablation zone are not usually dangerous for transport vehicles. In most cases, they are filled with frozen melt water. In the ice zone, they can also be open, especially before the beginning of the summer melting period. But the cracks in the cold firn zone of ice formation are dangerous. They are most often overlapped by snow bridges and are not noticeable. In October 1965, a tractor track fell through into one of them exactly at the place where the runway for ski-equipped aircraft landing was planned.

In 5-7 km to the ESE from the eastern tip of the Schirmacher Oasis where the ice flow streamlining the Oasis from the east is supported by a much stronger ice flow moving westward, several head anticlines were formed. They present gradually thinning ice barriers 500 to 1500 m long, 30-40 m wide and 3-7 m high. Some head anticlines are elongated almost rectilinearly, others are falciform or curved in the form of letter S. They are about ten and are observed only in this comparatively small area in the rear part of the ice shelf near the continental ice sheet slope.

From the beginning of the summer melting period, the on-ice streams make changes in the relief. Such streams create a sufficiently dense network. On some sites, there are around 100 streams on a 1 km segment. The channels of most of them are small. Their width is 10 to 50-60 cm, the depth is 5 to 20 cm and the length is several kilometers. The shores are precipitous and the bottom is flat. The farther the rivers flow, the more often they merge together forming even small rivers. The width of their channels comprises 4-5 m and the depth is 2 m. Flowing to depressions, melt waters can accumulate in large quantities and form on-ice lakes and "swamps"[7]. If the lakes are filled with melt water, the swamps contain water-saturated snow or water with snow. They are quite many at the surface of the ice shelf to the north and especially to the northwest of the Schirmacher Oasis, but they are widespread only in the ablation area. Their shape is usually round or oval, more rarely – falciform or elongated. The dimensions are very different from several square meters to 2 km^2. The depth of most of them is small – about 1 m. In winter, small lakes freeze to the bottom and their central portion bulges over 50-70 cm. The hillock is covered with cracks. Large lakes and swamps are dangerous. After the surface ice crust is formed, the water level gradually decreases and several intermediate ice crusts can form during this time. If the cracks exist, water can disappear at all. As a result, the lake basin dries up, but from above, it is overlapped by ice layers. A peculiar trap for transport vehicles is created. The dried up swamp is covered with a layer of ice lace – a delicate firn-ice mass. Even a pedestrian falls through to this mass.

The ice cryoconite glasses are quite widespread. They are many near the bedrock outcrops, especially from the leeward northwestern side. South to the Schirmacher Oasis at the continental ice sheet slope, the glasses are encountered at a distance of 2-3 km, north of its – on the ice shelf, up to 4-5 km and northwest of Bazisny and Kit nunataks – more than 10 km. Here, they are located at a distance of 1-5 m from each other. The farther from bedrock the fewer are the glasses. Their shape is more often round with a diameter of 10 to 60 cm, but some them achieve 1-1.5 m and whole ice depressions up to 2-3 m in diameter can be observed. They form due to combining of several glasses. The depth of some glasses is 60-100 cm and ice depressions – up to 1.5 cm.

Glaciological zonality

The difference of snow accumulation by areas is quite significant reaching sometimes 50 % and more (between 100-200 mm to 280 mm)[3]. The observations have confirmed the earlier observed typical features of uniform snow accumulation on the level horizontal surface of the ice shelf (on average, 210 mm/g). At the top of the Leningradsky Dome, it is almost twice as small (125 mm/g) and near its southern foot – approximately 280 to 400 mm/g (from readouts of several landmarks for different years). Near the foot of the northern slope of the Dome at the barrier, there is practically no snow accumulation as it is blown away by wind to the sea. The snow density is 0.41 at the level surface of the ice shelf, 0.44 at the top of the Leningradsky Dome and 0.39 g/cm^3 near its foot.

Summer melting here is small, all water formed seeps to the lower lying firn layers and freezes there in the form of comparatively thin ice interlayers, crusts and nodules. The entire area located north of 70^{o}23’ S and to the barrier belongs to the cold infiltration recrystallization (cold firn) ice formation zone. However, near the southern boundaries of this area (south of the road fork), the mean annual snow accumulation value slightly decreases to 100-150 mm/g. South of 70^o 23’ S, most of the ice shelf is grounded. That is why the level surface is replaced by gentle hillocks (with relative excesses comprising 50 m). Autumn-winter snow accumulation is small and all snow has time to melt. Most of melt water saturates the lower lying snow layers and freezes in the night hours forming superimposed ice. In other words, all indications of the infiltration-congelation (ice) zone of ice formation are observed here. Its northern boundary is quite sharply pronounced coinciding with the southern boundary of the floating ice shelf[3]. At this boundary, a narrow and broken transient firn-ice zone is noted. It is poorly developed and the firn-ice horizon is not greater than several tens of centimeters. The boundary between the ice zone and the ablation zone replacing it is unclear, it is conventionally drawn at 70°34' S. North of this line, one can observe the segments confined to the northern slopes of hills where melting predominates, while south of it at the southern slopes, there are segments where accumulation of superimposed ice occurs annually, i.e. a typical of the marginal parts of Antarctica motley alternation of the ablation and accumulation areas depending in this case on the relief. The surface of the glacier south of 70° 34'S also presents gentle hillocks with absolute heights of 70-110 m. Snow accumulation here is even less than in the ice zone being not greater than 10 cm thick (around 40 mm of water). In the band around 5 km wide elongated along the foot of the continental ice sheet slope, snow not only does not accumulate even in autumn and winter, but there is also sublimation of 10-15 cm of ice. Snow accumulation in the lower part of the continental ice sheet slope, which also belongs to the ablation zone is neither large. Typically in winter, snow patches confined to the leeward (northwestern) parts of the slope form here. Their area is different and can change between several to several thousand square meters with the thickness rarely exceeding 20-25 cm. The total area of the snow-covered segments is not more than 20-25% of the total slope area in this zone by the end of winter. Summer melting in the ablation zone is quite active. It usually begins in the first half of December and continues until the middle of February. According to some data, ice decrease from the ice shelf surface in spring-summer comprises 10 to 24 cm. Melt water forms a network of streams, which cover the slopes of the continental glacier from the foot (80-110 m) to a height of 300-350 m above the sea level, i.e. in a band 2 km wide. The southern boundary of the ablation zone is drawn exactly along the sources of these streams (70°46'-70°48' S)[3]. To the south of the ablation zone upward the continental ice sheet slope, an infiltration-congelation zone of ice formation extends. Here, at the parallel 70° 54'S in 4-5 km to the west of Bazisny nunatak, the airstrip location was chosen in January 1966. The snow cover studies made to clear up its suitability have shown that 25-30 cm of snow have accumulated during 1965, while below it there is a firn-ice layer (similar to the ice shelf) with a thickness of not more than 20-30 cm and a glacial ice below. This indicates that here similar to the northern boundary of the ice zone, the transition to the cold firn zone of ice formation occurs through the firn-ice zone. However, the conditions for its transformation to a solid zone are much more favorable than in the north as the relief is more smoothed. The width of this zone is small and farther north, it is replaced by a cold firn zone extending up to the ice belt elongated along the northern foots of the Wohlthat-Massif and the Muhlig-Hoffman Mountains. This location of the boundaries of the zones is typical of the warm summer. During the cold summer, the ablation zone strongly decreases transforming to a narrow band near the Schirmacher Oasis. Its width is from several tens to several hundreds of meters from the southern side of the Oasis and from several hundreds of meters to 2-3 km from the northern side of the Oasis. Only in the northwest from the Oasis, it is up to 10 km. The boundaries of the ice zone at the continental ice sheet slope sink to 70°47' near the western tip of the Oasis and to 70°52' S near the northern foots of the Bazisny and Kit nunataks. To the north of the Oasis, the ice zone has the same bounds. m